AMENDMENTS TO THE SPECIFICATION:

Please replace the paragraph beginning on p.14 at ln.1 with the following amended paragraph:

Platen 120 is a disk having a working face 122 with a radius that is larger than the diameter of substrate 180. Preferably, platen 120 is a solid disk except for portions the disk that have been removed to accommodate whole-substrate imaging system 105. However, it is not necessary that the disk be solid to practice this invention. Other arrangements such as a hollow disk or a thin, solid disk over a honeycomb core also work. Additionally, slit 130, which is shown throughout the many figures as being cut into platen 120 in a generally rectangular form, is not restricted to a rectangular form in the present invention. Slit 130 comprises an opening in platen ~~130~~ 120, which opening may comprise any shape through which light may pass for the purposes of capturing reflectance data from a substrate 180. Accordingly, slit 130 may be rectangular, circular, oblong, symmetrical, asymmetrical, or any other shape.

Please replace the paragraph beginning on p.15 at ln.1 with the following amended paragraph:

Illuminator bundle 174 is a bundle of optical fibers that ~~serve~~ couple light from optoelectronic assembly 115 to fiber assembly 125. Sensor bundle 172 is a bundle of optical fibers that ~~serve to~~ couple light reflected from substrate 180 to optoelectronic assembly 115.

Please replace the paragraph beginning on p.17 at ln.20 with the following amended paragraph:

FIG. 3 shows a simplified cross-sectional view of fiber assembly 125 prior to it being inserted into slit 130. Fiber assembly 125 has a nominally rectangular cross section with an active face 127 whose adjacent longitudinal edges are beveled to an angle α. The precise value of α is not important, and the beveled edged serve only to position fiber assembly 125 in slit 130. Face 127 may optionally comprise the optically transparent element 137 for allowing passage of light, whether reflected from the pad-contacting surface through ~~the~~ element 137 to sensor bundle 172, or transmitted through ~~the~~ element 137 from illuminator bundle 174. Transparent element

137 may be integral to fiber assembly 125, or it may be located elsewhere about the slit. Element 137 may comprise glass, plastic, water, an air gap, or any other transparent fluid or material suitable for the purpose. In other embodiments, element 137 may be integral to, or comprise in whole or in part, platen 120 or polish pad 135. For example, the embodiment of FIG. 3 shows polish pad 135 having element 137 in the form of a rectangular window formed therein so that element 137 is aligned with slit 130.

Please replace the paragraph beginning on p.18 at ln.14 with the following amended paragraph:

In operation, light from light source 160 propagates through illumination fiber 310a in illuminator bundle 174 to termination end 194a and through illumination fiber 330a to termination end 194b, and is emitted from face 127 of fiber assembly 125. Some of the light reflected from substrate 180 enters sensor fiber 320a through termination end 192a, which directs the light back to spectrometer 190 via sensor bundle 172.

Please replace the paragraph beginning on p.19 at ln.9 with the following amended paragraph:

Illuminator bundle 174 includes several hundred fibers per row of fibers. The number of rows of illumination fibers 310 times the thickness of the individual illumination fibers should be approximately 1 mm or larger. Likewise, the number of rows of illumination fibers 330 times the thickness of the individual illumination fibers should be approximately 1 mm or larger. By way of example, illuminator bundle 174 requires approximately 300 fibers per row of fibers if the fibers have a diameter of 0.75 mm and are arranged edge-to-edge as shown in FIG. 4A. Thus, with two rows of illumination fibers, illuminator bundle 174 requires a total of 600 fibers. Examples of illumination fiber configurations that work include a single row of fibers having a thickness of 0.75 mm ~~works~~, two rows of fibers having a thickness of 0.50 mm ~~works~~, and five rows of fibers having a thickness of 0.20 mm. The number of illumination fibers 310 and illumination fibers 330 depends on the desired resolution of the image formed using the apparatus of the present invention. The resolution is also affected by the amount of light available to shine on substrate 180, and by the rotation rates of ~~the~~ carrier 170 and of ~~the~~ platen

120, and to a lesser extent by R_{OFFSET}. By way of example, a preferred configuration involves approximately 600 illumination fibers and 300 sensor fibers with terminations 192a distributed along an overall length of 220 mm.

Please replace the paragraph beginning on p.22 at ln.28 with the following amended paragraph:

With reference to ~~FIG. 4~~ FIGS. 1 and 4A, sensor fibers 320 at the sensing end of sensor bundle 172 are preferably arranged in a sequence (e.g. left to right) that matches the sequence of fibers at the other end of sensor bundle ~~174 in FIG. 5~~ 172 (i.e. the end coupled to optoelectronics assembly 115). This arrangement preserves the orientation of data points and facilitates data processing. However, such a pre-determined sequence is not necessary to practice the present invention. The sequence of sensor fibers 320 can be arbitrary and unknown to facilitate fabrication of fiber ~~bundle 115~~ assembly 125 and sensor bundle ~~174~~ 172. To determine the actual sequence of fibers 320, light shined through each individual sensor fiber 320 is detected on 2-dimensional imager 580, thereby creating a map of input light to detected light. Once measured, this map is saved, and all subsequent measurements sorted out using this map. Data point spacing provided by the spatial field of the sensor fibers can thus be properly reconstructed by system controller 108 during the imaging process, regardless of sensor fiber sequence at either end.

Please replace the paragraph beginning on p.23 at ln.11 with the following amended paragraph:

~~FIG. 6 shows a portion of~~ FIGS. 6A-6E illustrate a preferred method of fabricating fiber assembly 125. Fiber assembly 125 further includes plate 610 and plate 630, both of which have a thickness approximately equal to half the radius of illumination fibers 310 so that together they have a thickness slightly greater than the radius of illumination fibers 310. Plate 610 is patterned with parallel grooves 620 to a depth of approximately the radius of sensor fibers 320, as shown in FIG. 6A. Plate 610 and plate 630 are made of metal such as aluminum or stainless steel. Electropolishing is used to form grooves 620. Plate 610 and plate 630 can also be made of other materials, e.g. silicon (with grooves 620 formed using lithographic techniques and etching).

Please replace the paragraph beginning on p.23 at ln.20 with the following amended paragraph:

Once ~~the~~ grooves 620 have been formed, sensor fibers 320 are positioned ~~in grooves 620~~ therein. Sensor fibers 320 are then secured in place using an epoxy-based adhesive (epoxy not shown). Referring to FIG. 6B, plate 630 is then positioned on top of sensor fibers 320 in grooves 620 of plate 610 and glued in place with epoxy ~~(also not shown)~~. Illumination fibers 310 are then positioned on the surface of plate 630 opposing grooves ~~625~~ 620, as shown in FIG. 6C, and secured in place using epoxy~~, as shown in FIG. 6C~~. Then, illumination fibers 330 are positioned on the surface of plate 610 opposing grooves 620, and secured in place using epoxy. This portion of the assembly process results in an end-view configuration as shown in FIG. 6C, and in side view as shown in FIG. 6D. The fibers are then cleaved and polished so that fiber ends ~~192~~ 192a, ~~and~~ 194a and 194b are co-planar, as shown in FIG. 6E. Illumination fibers 310 and illumination fibers 330 are then bundled to form illuminator bundle 174 using methods known in the art. Likewise, sensor fibers 320 are bundled to form sensor bundle 172.

Please replace the paragraph beginning on p.24 at ln.3 with the following amended paragraph:

~~FIG. 7 shows~~ FIGS. 7A-7C illustrate an alternate method of fabricating fiber assembly 125. Plate 610' and plate 630' are identical to plate 610 and plate 630 respectively, except that no grooves are formed. To obtain sensor fibers 320, sensor fibers 620 are positioned on plate 610', as shown in FIG. 7A, and secured in place using epoxy (not shown). Plate 630' is positioned ~~on~~ against sensor fibers 620 and secured in place using epoxy (not shown), as shown in FIG. 7B. The rest of the assembly is identical to that shown in FIG. 6. Once assembled, periodic sensor fibers, e.g. every sixth fiber, is selected to form sensor fibers 320, as shown in FIG. 7C.

Please replace the paragraph beginning on p.24 at ln.20 with the following amended paragraph:

The CMP system controller provides the rotation rate of platen 135, the rotation rate of carrier 170, and the angle reference signal. The angle reference signal constitutes a trigger signal, which, along with knowledge of the platen rotation rate, allows the whole-substrate imaging system 105 to initiate data collection just as fiber assembly 125 begins to pass beneath the leading edge of retaining ring 182 and to pause data collection just as fiber assembly 125 completes ~~is~~ its sweep beneath substrate 180 and the trailing edge of retaining ring 182. Thus, the position of the substrate 180 is known; however the rotational position of substrate 180 on carrier 170 is not known.

Please replace the paragraph beginning on p.25 at ln.10 with the following amended paragraph:

The spectrometer readout rate determines the sampling frequency. The platen rotation rate determines the amount of time fiber assembly 125 is under substrate 180, which when combined with the sampling frequency allows a user to select a suitable data density and hence image resolution. After collecting a set of line images collected during a single sweep, the data is corrected for the rotation of substrate 180 relative to platen ~~135~~ 120. The result is an image, which can be analyzed to yield significant process information. The data, either raw or processed, can also be stored to allow whole-substrate imaging system 105 to generate time dependent images of substrate 180 during CMP. These images can also be analyzed to produce a wealth of valuable process information.

Please replace the paragraph beginning on p.25 at ln.26 with the following amended paragraph:

In step 810, whole-substrate imaging system 105 acquires a sequence of line scans as fiber assembly 125 sweeps under carrier 170 holding substrate 180. Each line scan comprises a set of reflectance data from each of the sensor fibers 320 that make up sensor bundle 172. The sequence of line scans corresponding to a single sweep of fiber assembly 125 under carrier 170 forms a frame. ~~FIG. 9 shows~~ FIGS. 9A-9C show this process, and in particular ~~shows~~ show fiber

assembly 125 in each of three positions as it sweeps under substrate 180. ~~FIG. 9~~ FIGS. 9A-9C further ~~shows~~ show a trajectory 910 of sensor fiber 990 of fiber assembly 125.

Please replace the paragraph beginning on p.26 at ln.21 with the following amended paragraph:

Step 820 involves determining which frame contains the center point of substrate 180, which is necessary to enable the substrate image to be properly oriented. This step is also essential to allowing whole-substrate imaging system 105 to monitor specific sites on a wafer. Again referring to ~~FIG. 9~~ FIGS. 9A-9C, each frame includes a line image extending across substrate 180. For simplicity, ~~FIG. 9 shows~~ FIGS. 9A-9C show fiber assembly 125 having fewer sensors than would be used in practice. To facilitate the explanation of method 800 and the operation of whole substrate imaging system 105 only twelve sensors are shown even though in practice the apparatus of the present invention benefits from the presence of many more sensors.

Please replace the paragraph beginning on p.27 at ln.13 with the following amended paragraph:

~~In~~ FIG. 9B shows the position of fiber ~~sensor~~ assembly 125 at a slightly later time than in FIG. 9A. Sensor 960 and sensor 950 collect signature light from retaining ring 182. Ten sensors, including sensor 930, sensor 970, and all of the other sensors between sensor 930 and sensor 970 collect light reflected from substrate 180. ~~In~~ FIG. 9C shows the position of fiber sensor 125 at a slightly later time than in FIG. 9B. In FIG. 9C, sensor 930 and sensor 940 collect signature light from retaining ring 182. Seven sensors, including sensor 920, sensor 980, and all of the other sensors between sensor 920 and sensor 980 collect light reflected from substrate 180.

Please replace the paragraph beginning on p.30 at ln.11 with the following amended paragraph:

Because there are thousands of measurements made over the entire substrate, many options exist. Measurements can be made at specific sites on substrate 180, using site coordination information provided to ~~computer 160~~ controller 108 of whole-substrate imaging system 105 via rotating coupler 110. Such sites can correspond to specific die, or they can

correspond to well known measurement maps such as a polar map or Cartesian maps with 49 (or other) sites. Measurements using the apparatus of the present invention can also be used to determine such significant process performance characteristics as non-uniformity. Although such measurements are typically performed only after the completion of a CMP step, being able to report non-uniformity in addition to residual film thickness upon the completion of a CMP step is highly advantageous.

Please replace the paragraph beginning on p.32 at ln.7 with the following amended paragraph:

With reference to FIG. 11, whole die imaging system 105' includes a slit 130' formed in platen 120 so that the length of slit 130' is less than the diameter of substrate 180. A fiber assembly 125' disposed within slit ~~130~~ 130' is arranged along a radial line extending from rotational coupler 110. Polish pad 135 has a window 137' that is smaller than substrate 180, and that serves to allow light to be emitted from fiber assembly 125' and subsequently received by fiber assembly 125' upon reflection from substrate 180. The other elements in FIG. 11 are otherwise identical to those in FIG. 1. FIG. 12A shows the nominal position of fiber assembly 125' in slit 130', and arranged so that in normal operation, fiber assembly 125' passes under or nearly under the center of substrate 180. FIG. ~~12~~ 12B is otherwise identical to FIG. ~~2~~ 2B.

Please replace the paragraph beginning on p.32 at ln.17 with the following amended paragraph:

Fabrication of fiber assembly 125' is identical to that of fiber assembly 125 except that the overall length of fiber assembly 125' is chosen to be approximately as large as, or slightly larger than, the size of the die on substrate 180. In one embodiment, fiber assembly 125' has a length of 20 mm, corresponding to approximately 27 sensor fibers if the sensor fibers are located on .73 mm centers. Whole die imaging system 105' produces two-dimensional arrays of 10x10 to 20x20 data points ~~are obtained~~, depending on die size.

Please replace the paragraph beginning on p.35 at ln.9 with the following amended paragraph:

Depending on the length of fiber assembly 125' and the dimensions of die 1360 (which may differ as manufacturing needs change), swath ~~1330~~ 1320 may not necessarily include an entire die. In this case it is advantageous to detect streets, using techniques known in the art, and to compare the light reflected from quadrants surrounding an intersection 1370 of a street and a transverse street, as indicated by a spot 1382 in FIG. 15C. Since the die-to-die reflectance pattern is nominally the same, substrate orientation is determined uniquely once spot 1382 is located. With this technique it is not necessary that the length of fiber assembly 125' exceed the length of die 1360, i.e., it is not necessary that an entire die 1360 be imaged to determine the orientation of substrate 180, which significantly enhances the flexibility of the present invention. This technique requires only that sufficient sensor fibers 320 be included in fiber assembly 125' that intersection 1370 be identifiable and that the portions of die surrounding intersection 1370 be large enough that optical reflectance differences can be detected.

Please replace the paragraph beginning on p.36 at ln.8 with the following amended paragraph:

FIG. 16 shows a line imaging spectrometer 1611 that is ~~part of spectrometer 190. Line imaging spectrometer 1611 is~~ identical to line imaging spectrometer 511 except that sensor bundle 172 is replaced with lens assembly 1640 and slit 1650. Line imaging spectrometer 1611 further comprises a lens assembly 560, a diffraction grating 570, and a two-dimensional imager 580. Line imaging spectrometer 1611 operates as follows. Light from source 160 passes through illumination bundle 174, and impinges on a film contained on or in substrate 180. The light reflects off the wafer and is received by ~~sensor bundle 172~~ lens assembly 1640, which couples the light through slit 1650 ~~to lens assembly 560~~ ~~that~~ to produce ~~produces~~ a line image of a corresponding line on substrate 180. Optionally, slit 1650 may be placed in close proximity to substrate 180, and lens assembly 1640 may be omitted. The line image is coupled to lens assembly 560 and arranged along a spatial dimension. The line image passes through diffraction grating 570. Diffraction grating 570 receives the line image and dissects each subportion thereof into its constituent wavelength components, which are arranged along a spectral dimension. In

one implementation, the spectral dimension is perpendicular to the spatial dimension. The result is a two-dimensional spectral line image that is captured by two-dimensional imager 580. In one implementation, the imager is a CCD, the spatial dimension is the horizontal dimension, and the spectral dimension is the vertical dimension. In this implementation, the spectral components at each horizontal CCD pixel location along the slit image ~~is~~ <u>are</u> projected along the vertical dimension of the CCD array.